D. Indoor Air Quality

EXECUTIVE SUMMARY

Public Resources Code (PRC), Section 25402, requires the California Energy Commission (Commission) to develop, implement, and periodically update energy efficiency standards for new buildings. AB 4655 (Tanner, 1988) added PRC Section 25402.8, requiring the Commission to examine the effects of energy efficiency standards on indoor air quality. Specifically, this legislation requires the Commission to: a) include in its deliberations, while developing building standards, the impact these standards could have on indoor air quality; and b) to complete, by December 31, 1991, a review of current energy efficiency standards to determine whether modifications are needed to reduce the potential for indoor air pollution. This report is a summary of that review.

History of Concern over Indoor Air Quality

Combined, the following factors have raised concern over the impact of indoor pollutants on human health:

The discovery that high concentrations of the carcinogenic (cancer-causing) radon gas may be found in more homes than previously assumed

Discovery of the possibility of high levels of carcinogenic asbestos fibers in some buildings with past applications of asbestos, a widely used insulating material

Growing number of non-specific health symptoms, which tend to occur when exposed to indoor pollutants

Employment trends toward working indoors

Building industry trends toward controlled indoor environments without occupant access to system controls or operable windows

Building industry practices during the energy crisis of restricting, if not eliminating, the use of outside air in heating and cooling systems

Building energy standards' incorporation of infiltration control requirements to reduce uncontrolled building air leakage

The growing number of volatile organic compounds found in typical homes and offices because of the use of manufactured products

Summary of Knowledge About Indoor Air Pollutants, Health Effects, Tight Building Syndrome and Building Related Illness

The main classes of pollutants (described along with related health effects) are:

- Biological contaminants
- Radon
- Combustion products
- Particulate matter
- Volatile organic compounds (VOCs) and semi-volatile organic compounds (SOCs)

"Tight building syndrome" cannot be linked to specific exposure to specific pollutants; a building-related illness (such as Legionnaire's Disease) can. Multiple chemical sensitivity (MCS), also known as Environmental Illness (EI), affects a significant subset of the population, leading to a heightened chemical sensitivity well beyond the normal sensitivity of the rest of the population.

Conceptual Approaches to Regulating Environmental Pollutants and Their Applicability to Indoor Environments

Environmental pollutants are currently regulated according to their potential to cause cancer or health effects other than cancer. This potential is assessed through the health risk assessment process. However, this risk assessment process is not useful for establishing energy-conserving ventilation requirements for buildings since there is no numerical correlation between ventilation rates and specific levels at risk.

The main factors that will affect the concentration of indoor air pollutants include:

- Effectiveness of any ventilation system in removing pollutants
- Care and maintenance of a building and its related systems
- Behavior of the building occupants
- Existence of entry pathways for pollutants
- Overall "air tightness" of the building
- Existence of significant indoor sources of pollution

Technological Approaches To Reducing Indoors Pollutants

The California Department of Health Services and Air Resources Board has identified source elimination as the most effective, economical and reliable method for reducing indoor concentrations of pollutants, with ventilation necessary for further reducing residual indoor pollutant levels. Ventilation is sometimes the most practical solution to immediate indoor air quality problems involving specific indoor pollutants from identifiable sources. In general, maintaining acceptable indoor air quality involves the approach of eliminating all known sources and providing adequate ventilation.

The concentration of a pollutant in a space is a function of the source strength and the dilution rate. The effects of the dilution rate on source strength is not easily quantifiable and is generally considered to be variable making it impossible to establish specific ventilation rates appropriate to all situations.

When formulating ventilation requirements for the purposes of reducing potential for pollutant accumulation, it is difficult to establish any one pollutant as an indicator of the absence of pollution-related health effects. Carbon dioxide levels have been identified from experience and limited studies as a roughly reliable indicator of acceptable indoor air quality. Total volatile organic compound (TVOC) concentration has been applied with some limited success as a general indicator of indoor pollutant levels. No other pollutants have been identified so far as capable of such an indicator role.

ASHRAE Standard 62-1989 bases its minimum ventilation rate on the same principle of minimizing levels of carbon dioxide as a way of maintaining indoor pollution within acceptable levels, as well as a general belief that higher levels of dilution reduce the potential for adverse health effects of indoor air pollution. The other components of the standard are based on committee consensus. Scientists have attempted to establish health-protective ventilation rates by using pollutants other than carbon dioxide as a surrogate for pollutant levels, but direct relationships between pollutant concentration and ventilation rates are difficult to establish because of the many factors that can affect the concentration of pollutants in any indoor environment.

The removal of pollutants from space can be accomplished in two ways: the pollutant-laden air can be exhausted from the space or treated to remove the pollutants of concern. At present, only limited confidence can be placed in the effectiveness of air treatment systems for protecting against health effects of indoor pollution due to the following factors: 1) air treatment is presently possible for only a small group of indoor pollutants; 2) the safe levels of many of these pollutants have not been established.

California's Energy Efficiency Standards

The Commission is required to develop cost-effective energy efficiency standards that include both mandatory and performance requirements. CEQA specifically requires the Commission to identify any potential negative environmental effects of compliance with these standards and to present alternatives, which will mitigate these effects.

The efficiency standards have unique features that conceivably could lead to increased indoor concentrations of pollutants. These include infiltration control requirements and mandatory insulation levels. There are no specific requirements for mechanical ventilation of residential buildings. The Commission concludes that these requirements do not present a major risk of increased indoor pollutants and that residential buildings are adequately ventilated because of the universal application of operable windows.

The standards for nonresidential buildings have incorporated minimum ventilation requirements since their effective date in 1978. Two revisions of the standards reflect the following facts:

Revision of ASHRAE Standard 62 in 1981 and 1989

Further research pointing to the need for at least 15-cfm per person to ensure that the concentrations of pollutants do not pose a risk of significant health effects

The inappropriateness of distinguishing between smoking and non-smoking buildings given the large number of hazardous indoor pollutants

Conclusion that demand controlled ventilation based on the levels of an acceptable indicator pollutant is the only reliable performance-based ventilation method

The 1992 nonresidential ventilation requirements can be met through natural or mechanical ventilation. The natural ventilation provisions limit this option to certain building geometrics. The

mechanical ventilation requirements establish a minimum ventilation rate as the larger of a table value, in cfs per square foot, or 15 cfs per person. For office buildings, 0.15 cfs per square foot is required. This means that when an occupant density of 100 square feet per occupant is exceeded, the ventilation rate will be 15 cfs per person to reflect the increased need for carbon dioxide dilution.

The standards include provisions or requirements for the following:
Demand controlled ventilation
Supply of ventilation on a whole building basis
Pre-occupancy purge requirements
System control requirements
Requirements for supply of air to zonal heat pumps and fan coils
Completion and balancing requirements
The combined effects of higher ventilation rates and better efficiency requirements resulted in statewide energy savings. The Commission concluded the compliance with nonresidential standards would not lead to a significant increase in outdoor air pollution.

Commission's Strategy for Future Indoor Air Quality Research and Standards Development

Examination of the literature on indoor air quality issues shows substantial uncertainty about not only the best mechanisms for mitigating the problem in buildings, but also the essential elements of the problem being addressed in each situation. The Commission will continue examining these issues as part of the long-term plan to assess and update its building efficiency standards, as resources become available.
Based on the following key factors, the Commission is best equipped to establish ventilation rates for buildings covered by the energy efficiency standards.
The need for ventilation, and the extent of ventilation, should be determined from knowledge of the state's energy needs, as well as the magnitude of the indoor pollution problem.
Ventilation is not aimed at concentrations of single pollutants but at removing whole classes of pollutants.
The existing health risk assessment process is of limited usefulness in formulating specific numerical requirements for ventilation.
The Commission, since the first standards were established in 1978, has considered the impacts of its standards on indoor air quality in all of its revisions.

The Commission is the only agency assigned the task of balancing the impacts of its standards on both indoor and outdoor environments.
The Commission is able to assess the technological achievability, and cost effectiveness of its energy conservation standards.
The Commission's work to date includes:
Air leakage tests on pilot samples of homes built before and after the standards took effect.
Investigation of potential building elements that can affect indoor air quality and ventilation rates.
Participation of the Interagency Work Group on Indoor Air Quality, chaired by the Department of Health Services.
Revision of the minimum ventilation requirements for nonresidential buildings to reflect the latest understanding of the nature of pollution-related health effects.
Analysis of the potential impacts of compliance with the Commission's standards.
In complying with the statutory requirements of the Warren-Alquist Act, the Commission conducted an assessment of its building standards and indoor air quality during its 1992 revisions to the standards. The Commission concluded that the combined effects of occupant behavior, emission from pollutant sources and HVAC design necessitated substantial revisions to the nonresidential ventilation requirements. The Commission chose not to develop mechanical ventilation requirements for single family homes due to universal use of operable windows in homes.
Future work of the Commission, assuming availability of resources, will include:
Continued investigation and monitoring of both residential and nonresidential building air exchange rates.

Coordination with DHS, ARB, and federal agencies to develop a more reliable health risk assessment process for addressing indoor pollution problems.
Research in cooperation with ARB and DHS of the effectiveness of interim pollution reduction measures such as building commissioning and bake-outs.
Further research of ventilation effectiveness in terms of air mixing and the ability to remove the pollutants of most concern.
Continued standards refinement and public education efforts to help building occupants understand the factors affecting indoor air quality.
For detailed information, please request the following staff report from the Commission:
"California's Energy Efficiency Standards and Indoor Air Quality"